# FINAL REPORT ON THE INSTALLATION AND OPERATION OF TWO MERCURY RETORTS AT ICI CANADA INC., CORNWALL WORKS

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**SUBJECT:** REPORT ON THE INSTALLATION AND OPERATION OF TWO MERCURY RETORTS AT ICI CANADA INC., CORNWALL WORKS

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**FOR:** THE ONTARIO MINISTRY OF THE ENVIRONMENT
WASTE MANAGEMENT BRANCH
INDUSTRIAL 3Rs UNIT

**DATE:** APRIL 24, 1992

## ABSTRACT

The mercury retort project was to replace and improve upon a hydrogen burning mercury retort which had been constructed at Cornwall Works in 1939 and was not operated after 1987. A mercury retort is a device that removes mercury from mercury contaminated wastes by heating the waste in a chamber to a temperature which vopourizes the mercury. The mercury vapour diffuses out of the waste and is condensed and recovered for reuse as pure metallic mercury. The remaining waste(retort ash) has a much reduced concentration of mercury and can be more easily and safely disposed.

The retorts that we purchased were designed and manufactured in Europe and are successfully used there by the chloralkali industry. The technology appeared to be the best available at the time and two 300 litre capacity retorts were purchased with the expectation that we would have the capacity to treat and recover mercury from more than double the quantity of retortable waste that we generate. In addition, the manufacturer guaranteed that the retort ash would contain less than 25 ppm, thereby rendering it non-leachate toxic for mercury.

The retort project was approved in November, 1987 and the first charge was retorted in May, 1990. The total cost of the project was $630,000.

We have been successful in achieving the claimed reduction in mercury content. The average mercury content for all the acceptable retort ash is 10.5 ppm. In 1991, 10% of the charges had to be reburned, but none of them exceeded 36 ppm, so we should be able to get the reburn frequency even lower. The Regulation 309 leachate tests show the mercury concentration to be far below leachate toxic limits.

We have not yet nanaged to achieve the throughput that we targetted. This is due to several factors, of which the most important are; facility inoperable in cold weather, difficulties in handling the trays and removing retort ash and lack of operating personnel. We have taken steps to address some of the obstacles and others are still a problem.

## INSTALLATION AND OPERATION OF TWO MERCURY RETORTS AT ICI CORNWALL

### INTRODUCTION

The mercury retort project was intended to replace and improve upon a hydrogen burning mercury retort which had been constructed at Cornwall Works in 1939 and was not operated after 1987. A mercury retort is a device that removes mercury from mercury contaminated wastes by heating the waste in a chamber to a temperature which vopourizes the mercury. The mercury vapour diffuses out of the waste and is condensed and recovered for reuse as pure metallic mercury. The remaining waste(retort ash) has a much reduced concentration of mercury and can be more easily and safely disposed.

### Disadvantages of Old Retort

The old retort had an insufficient capacity to deal with the quantity of waste generated and a large backlog of untreated drums had resulted. In addition the old retort was not able to reduce the mercury in the retort ash to levels which would render the waste non-hazardous.

### ICI's Retort Proposal

It was proposed to install two 300 litre charge capacity retort units. Each unit would consist of a loading system, an oven and a distillation section which would remove the last traces of mercury from the vapours prior to discharge to the atmosphere. The units would be installed on a concrete pad and would be electrically heated.

### Advantages of/ Justification for Retort Proposal

The Swiss designed and manufactured retort units had been successfully used in European Chloralkali plants. The manufacturer guaranteed a performance of less than 25 ppm of mercury in the retort ash and our expectations were to obtain a typical mercury concentration of 10 to 15 ppm which we believed would render the ash non-leachate toxic for mercury. Two 300 litre capacity retorts were purchased. One 300 litre retort was expected to have the capacity to deal with the ongoing production of cellroom sludge and the acquisition of a second was to enable us to retort our considerable backlog of waste. An electrically heated retort was $50,000 less expensive to install than a natural gas or hydrogen fired unit and it offered the possibility of better and more uniform temperature control.

### Objectives

The above advantages and justification sum up the objectives of the proposal as 1) processing our retortable wastes so as the render the retort ash non-leachate toxic for mercury and 2) obtaining sufficient retort capacity to treat not only the wastes which we generate, but also the backlog accumulated on site.

# INSTALLATION AND OPERATION OF TWO MERCURY RETORTS AT ICI CORNWALL

The details of this introductory section are described in more detail in the November 18, 1987 proposal sent to Mr. Brandon Killaekei of the MoE Waste Management Branch. I have attached a copy of that submission for your reference.

## THE PROJECT

### Retort Project History

The following is a summary timeline for the ICI mercury retort project:

| | Date |
|---|---|
| Inquiries made regarding potential suppliers | Mar,Apr, 1987 |
| Ontario environmental C of A applied for | Oct, 1987 |
| Project approved within ICI(CIL) | Nov, 1987 |
| 3 R grant applied for | Nov, 1987 |
| Ontario environmental C of A approved | Dec, 1987 |
| 3 R grant approved | Jul, 1988 |
| Order for retorts placed | Aug, 1988 |
| Retorts received at ICI, Cornwall | Apr, 1989 |
| Commissioning started, first charges retorted | May, 1990 |

### Retort Installation Description

The retort installation consists of:

- a mixer to mix lime with the retortable waste
- a screw conveyor to load the waste into trays
- hemi-cylindrical 300 litre capacity trays
- track mounted buggies to position loaded trays in front of the retort ovens
- two electrically heated retort ovens
- for each retort, primary and secondary water wash towers to condense mercury from the carrier gas and a carbon column to reduce mercury levels in the discharged vapour to less than 0.1 $mg/m^3$
- holding tanks for the wash water, with a mercury settler at the bottom
- pumps and a cooling vessels to cool the wash tower water and permit its reuse
- system to vacuum the retort ash from the finished trays and pass it through a cyclone separator prior to loading it into drums.

The installation is located on a curbed concrete pad which has drainage trenches leading to a sump. Contents of the sump are pumped to the cellroom wastewater treatment plant(WWTP). The installation has a roof, but no walls. The MCC room and controls are located in part of an old boiler house building immediately adjacent to the retort.

The project was completed at a cost of $630,000.

**Retort Operation Description**

The retort operation consists of the following steps:

- a fork lift is used to bring drums of retortable mercury contaminated waste to the installation.
- free water on top of the drums is decanted to the trenches to be pumped for treatment at the cellroom WWTP.
- the drums are emptied into a mixer with a drum tipping device and lime is added and mixed in with the waste. The empty drums are washed and reused
- the waste is loaded into hemi-cylindrical trays via a screw conveyor
- with mechanical assistance, the trays are positioned in front of the ovens and then placed in the ovens
- the oven doors are closed and the heating cycle is started
- the electrically heated ovens are ramped up to 600°C and held there for several hours
- fresh air is drawn through the ovens by a 260 $m^3$/hour blower located on the discharge of the secondary wash tower. This air is the carrier gas for the mercury vapours
- the mercury in the waste is vapourized and diffuses through the waste and is carried by the air into the the primary wash tower where a direct contact water spray cools the gas and strips most of the mercury. A secondary wash tower further strips the mercury and a carbon column polishes the air before discharge to atmosphere.
- the wash water from both towers, carrying the mercury goes to the water holding tank where the mercury settles out. The water then goes through a series of cooling vessels prior to re-entering the cooling towers.
- the mercury is collected from the settling tanks
- after retorting is complete, the trays are allowed to cool down and a sample of ash is taken to the laboratory for mercury analysis.
- if the ash contains more than 25 mg/kg of mercury it is reburned
- if the ash contains less than 25 mg/kg mercury, it is removed from the tray by chipping the hardened material and vacuuming the ash out, through a cyclone separator into a plastic drum.
- the retort ash is being stored on site while we look into its waste category.

**Project Results Through 1991**

The project results can be evaluated by asking two questions; how much mercury contaminated waste have we been able to treat and what has been the effectiveness of the treatment?

In our proposal we had expected to burn two retort charges per day which, allowing 250 operating days per year, would amount to 500 retort charges per year. We currently generate retortable waste equivalent to 200 retort charges per year, thus the anticipated operating rate would have allowed 300 charges per year of backlog.

**Project Results Through 1991(cont'd)**
A summary of the amount of waste treated is shown in the table below. It can be seen that in 1991 we retorted only 113 charges, of which 102 had <25 mg/kg mercury.

Retort Operations Summary

| Period | Days Operating | Total Burns | Good Burns |
|---|---|---|---|
| Commissioning, May-Aug,1990 | | 24 | 14 |
| 1990, 3rd quarter | | 17 | 14 |
| 1991, 1st quarter | 4 | 3 | 3 |
| 1991, 2nd quarter | 32 | 26 | 22 |
| 1991, 3rd quarter | 31 | 35 | 33 |
| 1991, 4th quarter | 43 | 49 | 44 |
| 1991 Totals | 110 | 113 | 102 |

There were only 110 operating days. The days lost were because of weather (50%), operator unavailability (40%) or maintenance downtime (10%). The weather related downtime is addressed in the deficiencies section. In addition to the problem of too few operating days, we averaged only one charge per day. There were several reasons for this, mostly related to problems in handling the trays and removing the ash as well as poor control of the burn cycle. These problems are also addressed in the deficiencies section.

The retorts have been very effective in removing mercury from the waste. On average, the 133 acceptable batches produced from the commissioning period to the end of 1991 have contained 10.5 mg/kg of mercury, leaving, as a rough estimate, 0.2 kg of mercury in all the retort ash from these charges. We have recovered 1238 kg of free mercury from these batches. Although the mercury is first recovered as an amalgam, we obtain free metallic mercury by re-retorting the amalgam. The recovery rate for mercury based on these figures is 99.98% In 1991, almost 10% of the lots had to be reburned but these lots did not greatly exceed 25 mg/kg mercury, the highest being 36 mg/kg, so we should be able to reduce the number of reburns.

We have done Regulation 309 leachate tests on 7 samples of retort ash and have found the mercury concentration to range from 0.00008 to 0.0005 mg/L, averaging 0.00035 mg/l. The criterion for leachate toxicity is 0.1 mg/L of mercury. Therefore, the mercury remaining in this waste is virtually non leachable. We are in the process of examining other parameters vs. Reg. 309 in order to propose a category to the MoE.

**Project Results Through 1991(cont'd)**
As a matter of information, the air discharges from the retorts have been tested and average 0.008 and 0.006 mg/m$^3$ for retorts #1 and #2 respectively. The limit under our CofA is 0.100 mg/m$^3$.

## RESULTS AND CONCLUSIONS

The project has achieved the objective of obtaining a retort ash which is non-leachate toxic for mercury. We still have to complete evaluation of the waste for other Ontario Regulation 309 parameters in order to determine an appropriate category for the waste.

The objective of attaining sufficient capacity to treat not only the waste generated, but the backlog of waste has not yet been met. The main reasons for the inability to meet this objective are summarized in the following section on deficiencies.

### Deficiencies

The main hindrance to operating the retorts has been the weather. The lack of walls has exposed the installation to freezing and as a result we lost four and one-half operating months during our first winter. The installation was supplied with a weather shields and a heater on three sides for this past winter, but the mercury condensing end was still exposed and we lost about two and one-half months of operating time. The installation still needs more weather protection. With hindsight, location within the cellroom may have been preferrable.

The handling of the trays has been a problem. Originally designed to be manually pushed into the ovens and removed, we quickly found that a mechanical assist required and a manually operated winch was installed. We have now gone an hydraulically operated mechanism to insert and remove trays. The trays are approximately 2m long and they have warped, increasing our difficulty in inserting and removing them from the ovens. Two 1m trays for each may be preferrable.

The removal of the retorted material from the trays has often been difficult, requiring laborious chipping away at the hard material prior to vacuuming it out. The design of the trays with chimneys to promote even heating has made the chipping more difficult.

The retorts do not recover free metallic mercury, but an amalgam that we call thick mercury. We have not solved this problem, although it might be related to the reuse of the spray tower water. The thick mercury is re-retorted to make it free. This is a small inefficiency.

**Deficiencies(cont'd)**

The control mechanism for the burn cycle does not provide for an automatic stopping of the oven and we are not entirely satisfied with the control function. We feel that a better mechanism would be available and will look into this.

At the time that this project was done this technology, based in Europe, appeared to be the best available. However, the material handling and distillation parts of the unit were not designed and manufactured by them and they were unable to help us when we ran into problems. The overall service was poor.

## GENERAL DO'S AND DON'TS

When working with specialized waste handling equipment such as the retort, do, if possible, purchase a complete package so that the supplier assumes responsibility for auxiliary systems, such as the materials handling and spray towers, as well as the primary system.

With specific reference to mercury retorting, the Chlorine Institute, teamed with Hazen Industries and BEI Engineers/ Constructors Inc., conducted development trials for mercury retorting in 1991. They claim to have process which has two advantages over ours. It has a continuous feed and discharge which means higher throughput and it handles combustibles much more readily by operating at higher temperatures and scrubbing the discharge gas for combustion products such as $SO_2$. In order for us to handle combustibles, we need to prevent combustion by nitrogen purging, something we haven't yet tried. This retort, now marketed by BEI, appears to be superior to ours.